



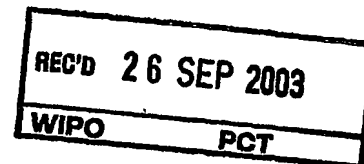
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Patentanmeldung Nr. Patent application No. Demande de brevet n°

02078972.3

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Application no.: 02078972.3
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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se référer à la description.)

Driving apparatus, use thereof and an optical system comprising such apparatus

In Anspruch genommene Priorität(en) / Priority(ies) claimed / Priorité(s)
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Driving apparatus, use thereof and an optical system comprising such apparatus

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The invention relates to a driving apparatus.

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Such an apparatus is known from practice and can be used in many different applications, in particular in applications wherein the driving apparatus has to be relatively small, such as in optical systems, zoom lenses, optical storage system drives, et cetera.

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US 5,225 941 describes a driving apparatus comprising a driving member which is frictionally engaged with a driven member. The frictional engagement is achieved using a leaf spring. A piezoelectric element is disposed in contact with the driving member
10 for movement thereof. During use, a saw-tooth voltage is applied to the piezoelectric element so as to make the speed of expansion of this element different from the speed of contraction thereof. Consequently, the driving member undergoes an alternating movement in opposite directions and with different speeds. The driving member moves the driven member only during the low speed motion thereof, leaving the driven member unmoved during the high
15 speed motion thereof, resulting in a certain displacement of the driven member.

A further embodiment is described in US 5,225,941, comprising two driving members, each of which is connected to a piezoelectric element, wherein each driving member is frictionally engaged with one respective driven member to change the position of that driven member. In that embodiment, each driving member provides a guiding support to
20 the other driven member. The friction between such a guiding support and the driven member has to be of relatively low friction to prevent clamping of the driven member during movement thereof. The American patent US 6,232,697 describes an alternative driving apparatus, comprising two driving shafts having piezoelectric elements, wherein the slow and rapid displacements of a first and a second piezoelectric element are applied at different
25 times.

A problem of the known apparatus is the inherent difficulty to tune the friction between the driving members and driven members appropriately on the one hand and to choose and control the speeds of the driving members on the other hand to such degree, that the driven members perform desired movements. A further problem is a relatively high

chance of failure of the apparatus. Such failure may arise when the friction between the driving member and the driven member varies during use. Variation of said friction may occur, for instance, because of certain contamination of the device, such as particles and/or dust unexpectedly present between a driving and a driven member. Furthermore, friction changes may arise from changing conditions of the environment, such as alteration of the humidity and/or temperature.

It is an object of the present invention to solve the above-mentioned problems, in particular to provide a relatively compact driving apparatus which has relatively little change of failure.

The present invention provides a driving apparatus, comprising at least two driving members and at least one driven member, wherein the at least two driving members are frictionally engaged to the at least one driven member to move said driven member, wherein the friction between each driven member and each driving member is such that the driven member moves when over half of the driving members being in frictional engagement with said driven member are moved between a first and a second position, wherein the friction between said driven member and each driving member is such that the driven member remains stationary when less than half of the driving members is moved.

This driving apparatus is relatively reliable, since at least two, and preferably three, driving members are provided to move each driven member using said friction which is provided between these members. This friction results in the driven member being moved or being held stationary in case over half of the driving members is or is not set in motion respectively. It follows that in case over half of the driving members is not set in motion, the remaining driving members can be moved without affecting the position of the driven member, for example to bring the remaining driving members back to a starting position. Preferably at least three driving members are provided to frictionally engage a driven member, so that two of the driving members can hold the driven member relatively firmly in position when the other driving member is moved back to a starting position, so as to avoid said other driving member pulling the driven member back with it.

Furthermore, the apparatus according to the invention has the advantage that it can be made relatively compact, robust and of relatively little parts. Consequently, the apparatus can be advantageously utilized in applications wherein little space is available, such as in certain optical systems.

The driving apparatus according to the present invention can advantageously be used by carrying out the following steps in an appropriate order:

a) over half of the driving members that are frictionally engaged to the driven member is moved from a first to a second position at substantially the same time; and

5 b) the driving members are returned from the second to the first position in groups comprising less than half of the driving members.

During step a), the driven member is moved by the driving members since over half of the driving members engaged thereto are moved in a certain desired direction at the same time. During step b), the driving members can be retracted back to the first position
10 without pulling the driven member back in a reversed direction, since groups comprising less than half the number of driving members are retracted one after another. After that, steps a) and b) may be repeated to move the driven member over a further distance in said desired direction.

Advantageously, more than one driven member are provided, which can be
15 independently moved by a number of driving members. For example, a first driving member can be frictionally engaged to a first driving member only, whereas a second driving member is frictionally engaged to a second driven member only. In that case, a third driving member can be provided which is frictionally engaged to both the first and second driven member. Then, the first driven member is movable by applying steps a) and b) to the first and third
20 driving member, irrespective of the condition of the second driving member. In the same manner, the second driven member is movable by applying steps a) and b) to the second and third driving member, irrespective of the condition of the first driving member.

Further advantageous embodiments of the driving apparatus according to the invention are described in the dependent claims.

25 The invention also relates to an optical system, comprising the driving apparatus according to the invention. Such a system includes a system carrying optical components. In the optical system according to the invention, the system is fixed to the driven member or members. The system can be used for writing information in or reading information from an optical disc, such as CD or DVD.

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The invention will now be described in more detail on the basis of exemplary embodiments shown in the accompanying drawings.

Fig 1 is a perspective view of a first embodiment of the invention;

Fig. 2 is a section over plane II of the view of Fig 1;

Fig. 3 is a perspective view of a second embodiment of the invention comprising three driving shafts and one stationary shaft;

Fig. 4 is a section IV of Fig. 3, showing the driving members engaging a first
5 driven member;

Fig. 5 is similar section as shown in Fig. 4, showing the driving members
engaging a second driven member; and

Fig. 6 is a section VI of Fig. 2, showing the driving members engaging a third
10 driven member;

Fig. 1 shows an embodiment of a driving apparatus, comprising three driving
members 1, 2, 3 and one driven member 5. The driven member 5 comprises a cylindrical
element. Each of the driving members 1, 2, 3 are frictionally engaged to the driven member 5
15 to move said driven member 5 over a distance L. To this end, each of the driving members
comprises an elongated member 1, 2, 3, particularly a shaft, which extends partially through
the cylindrical driven member 5. Further, the driving shafts 1, 2, 3 extend parallel and
adjacent to each other in a closely packed arrangement over said distance L. Therefore, the
three driving shafts 1, 2, 3 together form a guiding axis for guiding the cylindrical driven
20 member 5 over said distance L. It is to be observed that the prior art documents US 5,225 941
and US 6,232,697 disclose apparatus, wherein each driving shaft is frictionally engaged to
only one driven member for moving that driven member, leading to the abovementioned
problems. Further, said prior art discloses each driving shaft serving only as a low friction
guide shaft for an other driven member, therefore not being able to set the other driven
25 member in motion.

The three driving shafts 1, 2, 3 are movably supported on one end by a support
6. From this support 6, the driving shafts 1, 2, 3 extend along said distance L adjacent to each
other in said packed arrangement, then over a certain distance at relatively small angles away
from each other and finally through spaced apart apertures 10 of a first frame 9b towards a
30 second frame 9b. Each of the driving shafts 1, 2, 3 is provided with a flange 7 which is
movably arranged in a space 11 between said frames 9a, 9b, as is shown in Fig. 2. Both
frames 9 are provided with piezoelectric elements 8 which are arranged to engage said
flanges 7 for independently moving each of the driving shafts 1, 2, 3 over a relatively short
distance, said short distance being the width of said space 11 minus the thickness of said

flange 7. In particular, the piezoelectric elements 8 can move each driving shaft 1, 2, 3 between a first position wherein the respective flange 7 adjoins the first frame 9a, and a second position wherein the respective flange 7 adjoins the second frame 9b.

The friction between the cylindrical driven member 5 and each driving shaft 1, 2, 3 is such that the driven member 5 moves when at least two of the three driving shafts 1, 2, 3 are moved. Further, the friction between each driven member 5 and each driving shaft 1, 2, 3 is such that the driven member 5 remains still when each driving shaft 1, 2, 3 is moved by itself between the first and second position. To this end, the cylindrical driven member 5 may be of resilient material so as to engage each of the elongated driving shafts 1, 2, 3 resiliently. Further, each of the driving shafts 1, 2, 3 may have a specific outer surface roughness or smoothness and/or the driven member 5 may have a certain inner surface roughness or smoothness to provide a desired friction. For instance, the friction between the driven member 5 and each of the driving members 1, 2, 3 can be substantially equal. The driven member 5 may be part of or may be linked to a sledge 15. The sledge 15 may be part of an optical scanning system in which case the sledge carries optical components, such as an objective lens.

During use, the driven member 5 can be moved as follows along said distance L towards the pair of frames 9. First, during a step a) at least two but preferably all of the three driving shafts 1, 2, 3 are moved from said first to said second position by the piezoelectric elements 8 over the mentioned short distance at substantially the same time. Consequently, the driven member 5 is pulled along by the frictionally engaged driving shafts 1, 2, 3 over said short distance towards the first frame 9a. Next, during a step b), the driving shafts 1, 2, 3 are returned from the second to the first position in succession. Therefore, when returning each driving shaft the other two driving shafts restrain the driven member 5 from being pulled back by said returning driving shaft, so that the driven member 5 remains in position.

By repeating said steps a) and b), the driving shafts 1, 2, 3 can move the driven member 5 substantially over any part of the distance L. The chance of clamping between the driven member and each of said driving shafts 1, 2, 3 is relatively low, since the driving shafts 1, 2, 3 are arranged adjacent to each other such that together they form a guiding axis. The driving apparatus shown in Fig. 1 has relatively little change of failure, since three driving shafts are frictionally engaged to the driven member to carry out the above steps. In particular, during step b) the frictional restraining forces applied by the two motionless driving shafts on the driven member 5 will be considerably higher than a frictional pulling

force applied by the returning driving shaft thereon, so that each driving shaft can be returned safely to the first position without changing the position of the driven member 5. The driven member 5 can be moved in a reverse direction, towards the support 6, by applying said steps a) and b) whilst reversing the movements of the driving shafts 1, 2, 3.

5 Fig. 3 shows part of a second embodiment, comprising four substantially parallel shafts 1, 2, 3, 4, arranged in two separate closely packed formations so as to form a guiding axis for a driven member 5. In this embodiment, the first shaft 1, second shaft 2 and third shaft 3 are arranged in the same way as in the previous embodiment of Fig. 1, i.e. each of these shafts 1, 2, 3 is movable over said relatively short distance. The fourth shaft 4 is
10 unmovable.

One part of the four parallel driving shafts 1, 2, 3, 4 is packed such, that the second and fourth shaft 2, 4 abut each other, as is shown in section IV of Figs. 4 and 5. An other part of the four shafts 1, 2, 3, 4 is packed such, that the first and third 1, 3 abut each other, as is shown in section VI of in Fig. 6. In between said closely packed formations, the
15 shafts 1, 2, 3, 4 comprise a not closely packed formation.

The embodiment of Fig 3 can be used to move three driven members 5 independently of each other, which is illustrated in Figures 4-6 with three driven members 5a, 5b, 5c. To that end, each of the driven members 5 comprises a section of a cylindrical element, such that this driven member 5 can be frictionally engaged by only three of the four
20 shafts 1, 2, 3, 4 whilst the other of the shafts 1, 2, 3, 4 protrudes through the longitudinal aperture of the cylinder section.

In Fig. 4, a first driven member 5a surrounds parts of the first and second driving shaft 1, 2 and the stationary shaft 4 such that the driven member 5a is frictionally engaged by these three shafts 1, 2, 4. The third driving shaft 3 protrudes through the aperture
25 of the driven member 5a so that the third driving shaft 3 does not frictionally engage the driven member 5a. Said steps a) and b) are simply carried out using the first and second driving shaft 1, 2 in order to move the driven member 5a.

In Fig. 5, a second driven member 5b is frictionally engaged by the second and third driving shaft 2, 3 and by the stationary shaft 4. The first driving shaft 1 protrudes
30 through the aperture of the driven member 5a so that the first driving shaft 1 does not frictionally engage the driven member 5a. Consequently, for moving the second driven member 5b, said steps a) and b) are simply carried out using the second and third driving shaft 2, 3. This movement is independent of the movement of the first driven member 5a,

since the first driven member 5a is held in position by the first and fourth shaft 1, 4 during the movement of the second and third driving shaft 2, 3.

Figures 4 and 5 show utilization of the first packed formation of the four shafts 1-4 for moving two driven members 5a, 5b independently. Utilization of the second packed formation is shown in Fig. 6. Therein, a third driven member 5c is frictionally engaged by the first and third driving shaft 1, 3 and by the stationary shaft 4. In this case, the second driving shaft 2 protrudes through the aperture of the driven member 5c so that the second driving shaft 2 does not frictionally engage the driven member 5c. For moving the driven member 5c, said steps a) and b) are simply carried out using the first and third driving shaft 1, 3.

From the above it follows, that the first, second and third driven member 5a, 5b, 5c can also be moved in desired combinations at the same time by setting the appropriate combination of driving shafts 1, 2, 3 in motion.

Although the illustrative embodiments of the present invention have been described in greater detail with reference to the accompanying drawings, it is to be understood that the invention is not limited to those embodiments thereof. Various changes or modifications may be effected by one skilled in the art without departing from the scope or the spirit of the invention as defined in the claims.

For instance, each driving member may be formed in many different ways. Each driving member may comprise, for example, a wire, a shaft, a rod, a bar, a plate, or a combination of such and/or different elements. The driving member may comprises different materials, such as a metal, an alloy, a plastic or a combination of such and/or other materials.

During use, each driving member may be moved at different speeds for moving the driven member and/or for retracting the driving member in case the driving member must not move the driven member. Movement of each driving member can be accomplished by different means, such as piezoelectric elements, electrical actuators, electromagnets and alike.

Furthermore, the friction of the frictional engagement between the driven member and each of the driving members may be substantially equal or may differ. The frictional engagement may be provided in different way, for example using bearings or alike.

Besides, the apparatus may comprise more than four shafts to move a larger number of driven members. For example, in case the embodiment shown in Fig. 3 comprises five shafts, six independent translations can be carried out. It follows that the apparatus can still be relatively compact and simple for the case that the apparatus comprises a large number of driven members, since the number of driving members does not rise linearly with

the number of driven members, this in contrast to said known apparatus wherein one driving member is applied for the movement of one driven member.

Furthermore, each driven member may be formed in many different ways, and it may comprise many different materials, such as a metal, an alloy, a plastic or a combination of such and/or other materials.

CLAIMS:

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1. Driving apparatus, comprising at least two driving members and at least one driven member, wherein each of the at least two driving members are frictionally engaged to the at least one driven member to move said driven member, wherein the friction between each driven member and each driving member is such that the driven member moves when over half of the driving members being in frictional engagement with said driven member are moved simultaneously between a first and a second position, wherein the friction between each driven member and each driving member is such that the driven member substantially remains stationary when less than half of the driving members being in frictional engagement with said driven member is moved.

2. Driving apparatus according to claim 1, wherein the apparatus comprises at least two piezoelectric elements arranged to move the at least two driving members independently.

3. Driving apparatus according to claim 1 or 2, wherein the apparatus comprises at least three driving members.

4. Driving apparatus according to claim 3, wherein the apparatus comprises at least two driven members.

5. Driving apparatus according to claims 3 and 4, wherein a first driving member is frictionally engaged to a first driving member only, wherein a second driving member is frictionally engaged to a second driven member only, wherein a third driving member is frictionally engaged to both the first and second driven member.

6. Driving apparatus according to any of the preceding claims, wherein the apparatus comprises at least four driving members.

7. Driving apparatus according to any of the preceding claims, wherein the apparatus comprises at least three driven members.

8. Driving apparatus according to any of the preceding claims, wherein each of the driving members is at least partially surrounded by part of the at least one driven member.

5 9. Driving apparatus according to at least claims 5 and 8, wherein each driven member comprises a section of a substantially cylindrical element.

10. Driving apparatus according to any of the preceding claims, wherein each driving member comprises an elongated member.

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11. Driving apparatus according to any of the preceding claims, wherein the driving members are substantially parallel over a certain distance.

12. Driving apparatus according to claims 9 and 10, wherein the elongated driving members extend adjacent to each other over a certain distance.

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13. Use of a driving apparatus according to at least claim 1, wherein the following steps are carried out in an appropriate order to move each driven member:

a) over half of the driving members that are frictionally engaged to the driven member is moved from a first to a second position at substantially the same time; and
b) the driving members are returned from the second to the first position in groups comprising less than half of the driving members.

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14. Use according to claim 13, wherein said steps are repeated until said driven member has been moved over a desired distance.

25

15. Use according to claim 13 or 14, wherein step a) comprises moving driving members from the first to the second position.

16. Use according to any one of claims 13-15, wherein step b) comprises returning the driving members to the first position substantially one after another.

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17. Optical system, comprising a sledge and the driving apparatus according to any one of claims 1-13, wherein the sledge is fixed to the at least one driven member.

ABSTRACT:

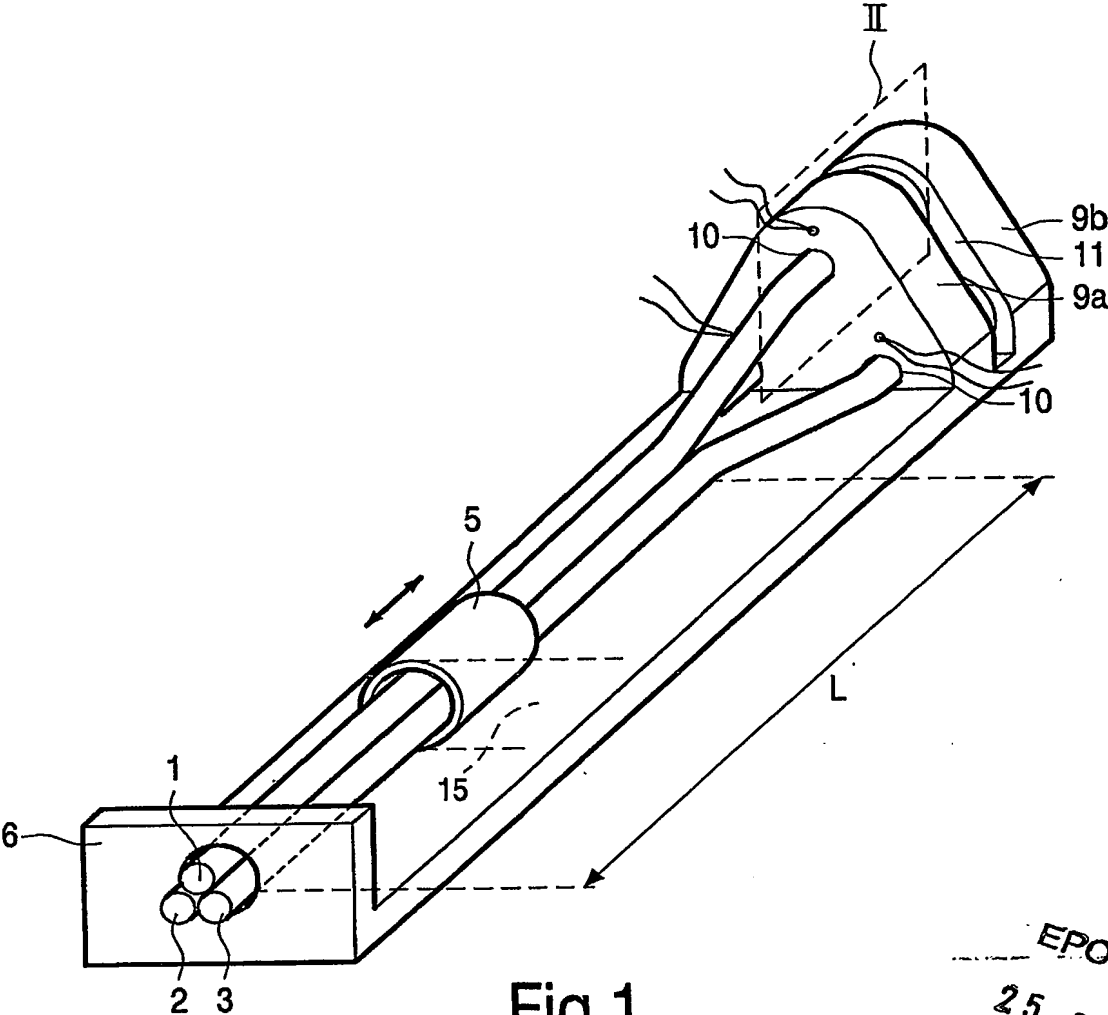
Driving apparatus, comprising at least two driving members (1, 2, 3, 4) and at least one driven member (5), wherein each of the at least two driving members are frictionally engaged to the at least one driven member (5) to move said driven member (5), wherein the friction between each driven member (5) and each driving member (1, 2, 3, 4) is such that the driven member moves when over half of the driving members (1, 2, 3, 4) being in frictional engagement with said driven member are moved simultaneously between a first and a second position, wherein the friction between each driven member (5) and each driving member (1, 2, 3, 4) is such that the driven member (5) substantially remains stationary when less than half of the driving members (1, 2, 3, 4) being in frictional engagement with said driven member is moved.

Fig. 1

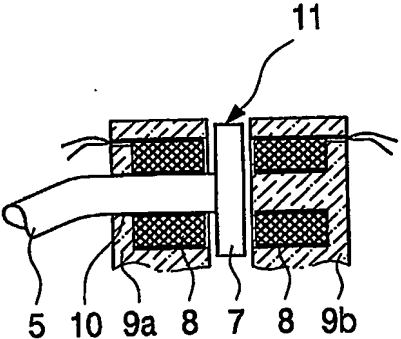
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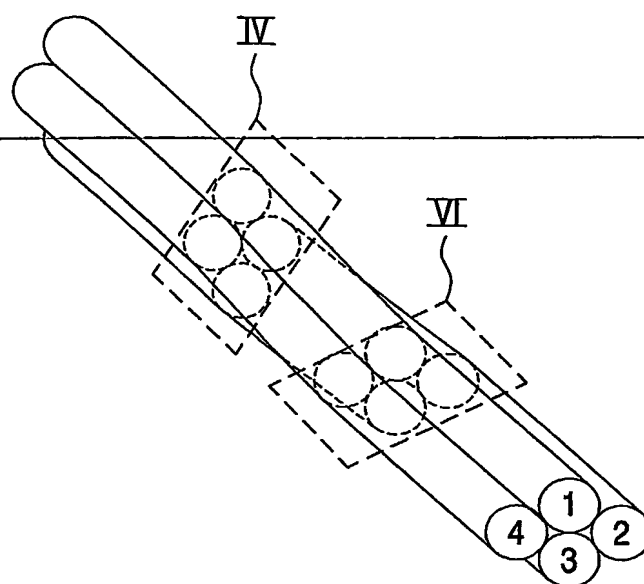


Fig.3

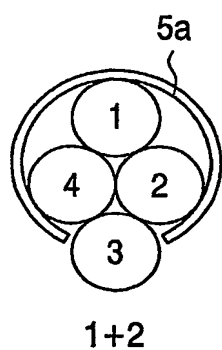


Fig.4

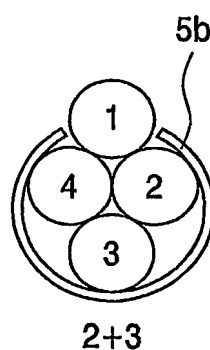


Fig.5

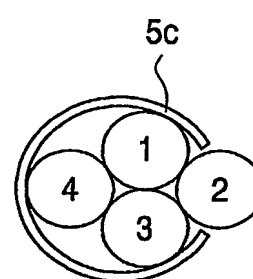


Fig.6